

**Lessons Learned:
Strengths-Based Approaches to Mathematics Education in the Pacific**

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Abstract

In this article, I examine through strengths-based approaches, current and future ethnomathematics research in the design and implementation of professional development for educators and teacher educators. The inclusion of mathematics indigenous to Hawai‘i and the Pacific leads to synergistic efforts and collective impact in global indigenous communities. By drawing on our unique strengths, we strive to create spaces and support voices that have and will continue to emerge in this work. This is accomplished by honoring culturally responsive, place-based strategies such as learning within and outside of the classroom and reshaping the curriculum in a cultural context. The expertise that exists in our communities, schools, and families is the foundation in the production of knowledge for empowerment to achieve equitable and quality mathematics education.

Keywords: Mathematics Achievement; Equity; Ethnomathematics; College, Career, and Community Readiness

**Ma ka hana ka ‘ike
*In working one learns***

The ‘ōlelo no‘eau (proverb) above frames the content of this article (Pukui, 1993, p. 227).

Through culturally responsive and place-based learning, we deepen our perspectives by doing mathematics that permeates our environments, values, and traditions.

Background

Several years ago, I published an article “Bridging Policy and Practice with Ethnomathematics” (2013) on research conducted at U.S. higher educational institutions (Harvard University, UCLA, University of Hawai‘i) in the field of ethnomathematics. The discussion focused on first,

how cultural values affect teaching, learning, and curriculum; and second, how mathematics education affects schooling process dynamics. Examining the Ethnomathematics Institute, a National Science Foundation-funded project, and the role of navigation in mathematics of the Pacific did specifically this. Through research and praxis, I highlighted the effectiveness of ethnomathematics as a bridge between policies introduced at the macroperspective level and hands-on learning experiences in the communities we are endeavoring to serve by building partnerships and mentoring in diverse populations. While these promising practices still hold true, new lessons have unfolded and been refined through strengths-based approaches with current and future implications.

Since 2013, collective impact in our networked communities and strategic partnerships (Kania & Kramer, 2011; Waitzer & Paul, 2011) has led to tremendous progress. Now in its eighth year, the Ethnomathematics and STEM Institute (EthnoSTEM) transitioned from a 2-week summer program to a yearlong professional development institute for P–20 STEM educators. Drawing on island wisdom to make global connections, EthnoSTEM is designed to utilize the local environment and community as a contextualized classroom. As this article will discuss, EthnoSTEM is guided by the mission and values of the Polynesian Voyaging Society and its traditional double-hulled voyaging canoe Hōkūle‘a. Hōkūle‘a, star of gladness, is internationally renowned for the role it has played in rekindling the Pacific Island tradition of non-instrument, wayfinding techniques based on celestial navigation (i.e., sun, moon, stars, winds). Over the past 40 years, Hōkūle‘a has sailed more than 150,000 nautical miles since the first trans-archipelagic, traditionally navigated voyage in 600 years—from Hawai‘i to Tahiti—in 1976. The current 50,000 nautical mile, 2013–2017 Mālama Honua Worldwide Voyage is the ideal vehicle to explore real-world STEM applications through indigenous and 21st century learning. The author

was invited to be part of the first international leg from Hawai‘i to Tahiti as apprentice navigator and education specialist, and subsequent voyages to the Samoan Islands, Olohega (Swain’s Island), Aotearoa (New Zealand), South Africa, Washington, D.C., and New York City.

In light of these developments, I will examine current and future ethnomathematics research in the design and implementation of professional development for educators and teacher educators. The inclusion of mathematics indigenous to Hawai‘i and the Pacific leads to synergistic efforts and collective impact in global indigenous communities (Furuto, 2014). By drawing on our unique strengths, we strive to create spaces and support voices that have and will continue to emerge in this work. This is accomplished by honoring culturally responsive, place-based strategies such as learning within and outside of the classroom and reshaping the curriculum (Maton, Schellenbach, Leadbeater, & Solarz, 2003; Meyer, 2003). Place-based strategies recognize the importance of including students’ cultural contexts in all aspects of learning (Ladson-Billings, 1995). The expertise that exists in our communities, schools, and families is the foundation in the production of knowledge for empowerment to achieve equitable and quality mathematics education (Fetterman, 2000; Hall, 1993).

From a body of research we deduce that strengths-based approaches are necessary to effectively teach and learn in diverse classrooms (PREL, 1995; Tuhiwai Smith, 1999). The literature highlights the need for pedagogy to align with assets of today’s students, and “requires a strong commitment by participating researchers and practitioners to share their expertise with the people, while recognizing the communities directly involved” (Sohng, 1998, p. 187). According to Kana‘iaupuni (2005), “Strengths-based research begins with the premise of creating social change. It means treating the subjects of study as actors within multi-layered contexts and employing the multiple strengths of individuals, families and communities to overcome or

prevent difficulties...the purpose of strengths-based research and evaluation is to benefit the people involved in the study by giving them voice, insight, and political power” (p. 35). This is demonstrated in the words of EthnoSTEM teacher participant Kelsey Amos, “A foundational idea is that there is not just one math—the math we learned in school. Rather, all cultures develop mathematical practices and applied technologies, and these are worth paying attention to. Ethnomathematics is the act of recovering cultural dignity for all people by helping us strengthen our roots” (personal communication, December 13, 2015).

Pacific Ethnomathematics

Ethnomathematics is defined as the intersection of culture, historical traditions, and sociocultural roots, among others. It celebrates diverse systems and frameworks that have served many cultures well in the teaching and learning of mathematical activities (D’Ambrosio, 2001; Kyselka, 1987). Current efforts in this field orient educators to discover pathways for student engagement, and support multiple approaches to learning mathematics within formal and informal environments. A strong component of ethnomathematics is finding relevance in real-world applications through physical, environmental, spiritual, and cultural capacities (Gay, 2000; Kawakami, 2003; Ladson-Billings, 1995).

The Pacific region faces challenges and opportunities of diverse populations spread over expansive geographical areas, combined with a long history of local control of education and politicization of efforts to implement reforms and standards on a national scale (Ascher, 1998; Greer, Mukhodpadhyay, Powell, & Nelson-Barber, 2009; Weiss & Miller, 2006). The focus on local control provides a wealth of perspectives and approaches, and fertile soil in which to conduct mathematics education research. For example, the State of Hawai‘i has been a national leader in place-based education and in connecting students’ classroom learning to a broader

cultural context through the field of ethnomathematics (Baybayan, Finney, Kilonsky, & Thompson, 1987; Chinn, 2011; Goetzfridt, 2008). It is through the lens of ethnomathematics that we explore *ma ka hana ka 'ike* (in working one learns).

A prominent example of *ma ka hana ka 'ike* is the 2013–2017 Mālama Honua Worldwide Voyage (WWV) of the double-hulled Pacific Island voyaging canoe Hōkūle‘a. By wayfinding without the guidance of modern instruments, the WWV blends indigenous traditions with innovative technology to map a course for the future. The mission of the voyage, *mālama honua* (to care for Island Earth), invites people across the world to join us in exploring values and practices that can sustain our planet. Living on an island chain teaches us that our natural world is a gift with limits and that we must carefully steward this gift if we are to survive together. As we work to protect cultural and environmental resources for our children’s futures, Pacific voyaging traditions and STEM tools allow us to venture abroad so that we may learn from and with others. Most recently, Hōkūle‘a arrived in Cuba and is headed up the U.S. east coast, where the author will next join the crew in Washington, D.C. and New York City before the canoe sails through the Panama Canal back to Hawai‘i in 2017.

Over the past several years, we have received declarations and pledges to care for Island Earth by French Polynesia President Gaston Flosse upon arrival in Tahiti, sailing with the United Nations Secretary General Ban Ki-moon in Samoa, discussing education and universal human values with His Holiness the 14th Dalai Lama, and conversing with Nobel Peace laureate Desmond Mpilo Tutu in South Africa. It was incredible being with these extraordinary leaders; however, the highlight is being with the children. Thousands of children have experienced the floating classroom Hōkūle‘a, which is a model of island sustainability and exploration of STEM principles. According to His Excellency Ban Ki-moon in a handwritten message being carried on

Hōkūle‘a around the globe, “I am honored to be a part of the Worldwide Voyage. Its global mission inspires me. As you tour the globe, I will rally more leaders to our common cause of ushering in a more sustainable future, and a life of dignity for all” (B. Ki-moon, personal communication, August 31, 2014). Archbishop Desmond Mpilo Tutu added his support of STEM education while in South Africa, “We have just one planet home. This is an issue of whether we want to survive as a species or not, and we can do this through teaching the children science, technology, engineering, and mathematics” (D. Tutu, personal communication, November 14, 2015).

The WWV has impacted educational efforts abroad, as well as at home in the Pacific. The Polynesian Voyaging Society Education *Hui* (group) was formed to strategically align the missions, visions, and values of early childhood education through graduate institutions with the WWV. After participating in WWV in Aotearoa, University of Hawai‘i System (UHS) President David Lassner and Polynesian Voyaging Society (PVS) Executive Director and Master Navigator Nainoa Thompson asked the author to be the UHS representative to the PVS Education Hui. In this capacity, we convened the UHS on both O‘ahu Island and Hawai‘i Island to strengthen current UHS initiatives in STEM, sustainability, and becoming a model indigenous-serving institution through the WWV. In addition, the UHS Board of Regents participated in a sail, and acknowledged the importance of *‘ike Hawai‘i* (knowledge of Hawai‘i) in teaching, research, and service to our communities. According to UH Hilo Chancellor Donald Straney, “It is through this type of collaborative work, learning from each other, that the University of Hawai‘i can fulfill our responsibilities to the indigenous people of Hawai‘i” (D. Straney, personal communication, February 12, 2016).

As another direct result of PVS Education Hui collaborations, Nā Hopena A‘o Cultural Pathways are one of the outcomes from the Hawai‘i State Department of Education (HIDOE). Nā Hopena A‘o Cultural Pathways are a statewide framework to develop the skills, behaviors and dispositions that are reminiscent of Hawai‘i’s unique context, and to honor the qualities and values of the indigenous language and culture of Hawai‘i (HIDOE, 2015). According to the HIDOE Office of Hawaiian Education, “Nā Hopena A‘o are a reflection of this special place, six outcomes to be strengthened in every student over the course of their K–12 learning journey—Belonging, Responsibility, Excellence, Aloha, Total Well-being, and Hawai‘i. When taken together, these outcomes become the core BREATH that can be drawn on for strength and stability throughout school and beyond to succeed in college, careers and communities” (p. 1). The intra- and inter-organizational work we are engaged in is the foundation for current and future ethnomathematics research in the design of professional development for educators and teacher educators.

Professional Development for Educators and Teacher Educators

Now in its eighth year, the Ethnomathematics and STEM Institute (EthnoSTEM) is an effort to address issues of equitable and quality education through culturally responsive STEM pedagogy. From 2008–2012, the Ethnomathematics Institute was a 2-week summer program for undergraduate STEM majors when the author was an Associate Professor of Mathematics at the University of Hawai‘i – West O‘ahu. The past three years, 2013–2016, represent a shift to a yearlong institute focusing on P–20 STEM teacher education as the author is currently an Associate Professor of Mathematics Education at the University of Hawai‘i at Mānoa. Research and data presented in this section are from the two completed years, 2013–2015, involving P–20 STEM educators. Our partners across Hawai‘i and the Pacific include the University of Hawai‘i

System, Hawai‘i State Department of Education, Hawai‘i P–20 Partnerships for Education, Pacific American Foundation, Pacific Resources for Education and Learning, and Polynesian Voyaging Society. The WWV has served as a creative vehicle to develop alliances spanning P–20 education levels, public and private sectors, and invites new partners by leveraging social innovations (Bryk, Gomez, & Grunow, 2011).

The three main EthnoSTEM objectives are to: (1) explore promising practices in STEM courses in diverse, high needs populations through national and state standards (i.e., Mathematics Common Core State Standards, Next Generation Science Standards, Nā Hopena A‘o Cultural Pathways); (2) strengthen campus-community partnerships and build a research consortium within Hawai‘i and the Pacific; and (3) commit to high-quality professional learning that is relevant, contextualized, and sustainable.

EthnoSTEM encourages investigations and adaptations of traditional and 21st century knowledge within formal and informal environments. In addition to classroom learning, place-based learning occurs throughout the Hawaiian Islands from skies to seas. For example, through traditional wayfinding techniques with the Polynesian Voyaging Society, we integrate trigonometry and analytic geometry with celestial navigation utilizing the sky as a textbook for estimating latitude and position. At Waimea Valley, participants discover intersections of tropical ecology and measurement through traditional rock wall building using vectors without cement or modern implements. At the 400-year old Waikalua Loko I‘a, participants help restore the fishpond and experiment with engineering skills involved in structural design and biodiversity of microclimates. Here, participants have an opportunity to investigate bioacoustics through sinusoidal curves and the impact of sound waves on fishpond walls. The culminating experience, Kalaupapa, Moloka‘i, was once a leprosy community in isolation, and now serves as

a place for education and contemplation. Our experiences are grounded in service learning, and we strive to always give back to Island Earth. As an example of service learning, in the past we cleared the Baldwin Boys' Home to give the patients a place to rest and relax in their natural environment. In the process, we had active dialogues about concave down parabolas and vertices as we threw debris into the back of a truck.

The in-service and pre-service teacher participants are selected to create a diverse group spanning a broad range of experiences, subjects and grade levels, and geographical locations.

Demographic information on the past two cohorts of EthnoSTEM participants representing 34 P–20 schools from across the Hawaiian Islands is provided in Table 1. One of the 40 participants was unable to complete the program.

Table 1. Demographic Information on EthnoSTEM Participants.

Characteristics	No. of teachers
<i>Grade level taught during study year (N = 39):</i>	
Elementary school (Grades K–5)	8
Middle school (Grades 6–8)	9
High school (Grades 9–12)	14
District resource teacher (K–12)	2
Undergraduate students	3
Post-secondary teachers	3
<i>Island (N = 39):</i>	
O'ahu	30
Hawai'i	4
Kaua'i	2
Maui	3
<i>Ethnic background (N = 39):</i>	
Asian	12
Caucasian	15
Native Hawaiian	9
Hispanic	2
Pacific Islander	2
Mixed	2
<i>Number of years teaching (n = 34)^a:</i>	
<1	1
1–4	11
5–10	5
11–15	6
>15	11
<i>School type (n = 34)^a:</i>	

Public	29
Public charter	4
Private	1
<i>Disciplines taught during study year (n = 34)^{ab}:</i>	
Education	2
English	2
Math	21
Science	16
Technology	1
All subjects (elementary)	1
College preparation	1
<i>Pre-service teachers—number of years until degree completion (n = 8)^c:</i>	
<1 year	5
1 year	2
2 years	1
<i>Subjects taught during the study year (n = 34)^b:</i>	
Algebra, Art, Biology, Chemistry, College Preparation, Elementary Education, English, Graphic Technology, Health, Language Arts, Marine Science, Mathematics, Math for Elementary Teachers, Math Resource, Modeling Our World, Natural Resources, Physical Science, Physics, Pre-Algebra, Pre-Calculus, Robotics, Science, Science Literacy, Social Studies	

^aThese questions were only asked of in-service teachers (n = 34). ^bThe in-service teachers were asked to list all subjects taught during the program year. ^cThese questions were only asked of participants who identified themselves as students (n = 8). Four of these participants were undergraduate pre-service teachers, four were full-time in-service teachers who were also enrolled in graduate school.

Professional Development Structure

During the yearlong EthnoSTEM institute, participants meet four times face-to-face (with sessions lasting from one to seven days) and once online, for a total of 132 direct contact hours over 13 days. The extended intervention is designed to allow facilitators to build a supportive network and offer a variety of avenues for the participants to engage with the material. The professional development structure consists of a two-day intensive orientation focused on introducing and laying the foundation and building community, three one-day workshops centered around themes that expose the teachers to different ethnomathematics promising practices and strategies through field experiences (respectively called PD1, PD2, and PD3), and a one-week summer immersion (see Figure 1).

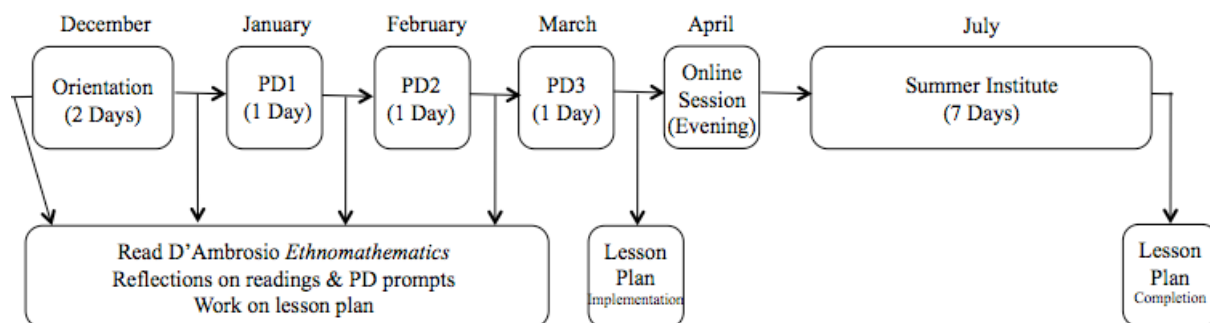


Figure 1 EthnoSTEM Professional Development Structure

Professional development workshops are linked through participant reflections on readings and individualized progress on the creation and implementation of lesson plans. As the EthnoSTEM culminating project, the final lesson plan is intended to reflect the participants' understandings of how to adapt concepts into their classrooms. In addition to having an overarching theme, each EthnoSTEM day focuses on a different Hawaiian value. These are aligned with the PVS and WWV values:

Aloha:	To show kindness/compassion
‘Imi ‘ike:	To seek knowledge
Lokomaika‘i:	To share
Mahalo:	To show gratitude/respect
Mālama:	To care for
Na‘au pono:	To be just
Olakino maika‘i:	To live healthily
Laulima:	To work together

The 20 participants are divided into five *hui* (groups) of four participants each. Each group is mentored by a project team *hui* advisor. Two of the EthnoSTEM alumni have become *hui* advisors. After completing his first year as a participant, Kaipo Tam, Ke Kula Kaiapuni ‘o

Ānuenue mathematics teacher, expressed the importance of the EthnoSTEM guiding values in his reflection (personal communication, July 20, 2014):

The Ethnomathematics and STEM Institute has helped me personally and professionally. This institute has allowed me to see math and science in a way that our kids can learn that's meaningful, and that they can use in their everyday lives as we laulima. I love dancing hula, weaving lauhala, and I've always wondered how I could incorporate them into a math classroom. Through 'imi 'ike, I can show my kids that culture can be incorporated into math and love what our ancestors have done for centuries, and continue to be a 21st century student and citizen of this world. I'm so excited to go back to school in a couple of weeks and showcase what I've learned and mahalo the institute for everything it has done for us. We can make a big difference, not only in our classrooms but in the State of Hawai'i.

The EthnoSTEM website contain a curriculum database of lesson plans created and implemented by participants, including topics such as the “Fibonacci Sequence in Nature”, “A Splash of STEM Through Aquaponics”, “Cartesian Coordinates and Weaving”, “Exploring Ocean Waves with the Sine Curve”, and the “Hawaiian Star Compass and the Unit Circle” (see <http://ethnomath.coe.hawaii.edu>). EthnoSTEM has been featured in articles, press releases, television, and other media locally and nationally (Hawai'i Public Radio, 2010; Mathematical Association of America, 2011; Pacific Business News, 2007; PBS Hawai'i, 2016; University of Hawai'i Systemwide News, 2016).

Evaluation Results and Findings

The University of Hawai'i at Mānoa Curriculum Research & Development Group conducts project evaluation. The evaluation of EthnoSTEM utilizes a mixed-methods approach, and evaluators use instruments for collecting formative and summative information. The main methods of data collection are observations, surveys, focus group interviews, and reflections after every professional development component. The six evaluation questions are presented in

Table 2. The analyses consist of descriptive statistics for quantitative data, and qualitative

analysis using a grounded theory approach for constructed-response questions (Corbin & Strauss, 2008).

Table 2. EthnoSTEM Program Goals and Evaluation Questions.

Goals	Evaluation Questions
Increase content knowledge and pedagogy in culturally responsive STEM based on the Common Core State Standards (CCSS), Next Generation Science Standards (NGSS), and Nā Hopena A‘o (HĀ) Cultural Pathways.	1. To what extent did the participants perceive that the professional development (PD) affected their knowledge of culturally responsive STEM pedagogies based on CCSS, NGSS, and HĀ?
Explore connections to STEM courses through curriculum design, implementation, and assessment.	2. Did the participants experience the project as valuable and relevant to their ongoing learning and teaching practices?
Foster teachers’ understanding of the design and implementation of STEM units based on CCSS, NGSS, and HĀ that include a service-learning component.	3. How did the participants perceive the process of their lesson plan development and implementation?
Establish campus-community partnerships in the State of Hawai‘i and Pacific for sustainable classroom and community networks.	4. To what extent did the participants perceive that their participation in the PD changed their teaching practice?
	5. To what extent did the participants report the PD cultivated a supportive, sustained community?
	6. To what extent were the PD’s activities being conducted as expected?

Changes in Teaching Practices

Overall, the participants perceived the professional development experience to be valuable and relevant to their teaching practice ($N = 39$, $M = 4.87$, $SD = 0.34$). In addition, at the end of the yearlong program, the participants were most likely to agree they understood and could incorporate culturally responsive pedagogy, STEM content, CCSS, and NGSS into their teaching practice (see Table 3). Disaggregated, the four items on “understanding” had a reliability of 0.69 (Cronbach’s alpha) and an overall mean of 4.18; the four items on “incorporation” had a reliability of 0.75 and an overall mean of 4.23.

Table 3. Understanding and Incorporation of Pedagogy, Content, and Standards.

Prompt	Construct	<i>N</i>	<i>M</i>	<i>SD</i>
1. The professional development (PD) helped me to better my understanding of culturally responsive pedagogy.	Understand pedagogy	39	4.82	0.39

2.	The PD helped me to understand how to incorporate culturally responsive pedagogy into my teaching practice.	Incorporate pedagogy	39	4.81	0.36
3.	The PD helped me to better understand how to incorporate STEM content into my teaching practice.	Incorporate STEM content	39	4.46	0.70
4.	The PD helped me to better my understanding of STEM content.	Understand STEM content	39	4.44	0.71
5.	The PD helped me to better understand how to incorporate the math Common Core State Standards (CCSS) into my teaching	Incorporate CCSS	39	3.95	0.89
6.	The PD helped me to better my understanding of the math CCSS.	Understand CCSS	39	3.79	0.76
7.	The PD helped me to better my understanding of the Next Generation Science Standards (NGSS).	Understand NGSS	39	3.68	0.96
8.	The PD helped me to better understand how to incorporate the NGSS into my teaching practice.	Incorporate NGSS	39	3.68	1.01
9.	The PD as a whole was valuable and relevant to my teaching practice.	Overall experience	39	4.87	0.34

When asked to give specific examples of how their teaching practices have changed, most participants indicated that the professional development encouraged them to modify curriculum materials to make them more relevant to their students through cultural activities and place-based connections. The teachers were also encouraged to do more hands-on activities, service learning, and project-based learning. One participant said the professional development validated his teaching philosophy, “Although I was encouraged to be culturally responsive in my teaching, I was not taught how to do it in my teacher preparation program. This PD showed me that we have resources in our own backyard that we can use to enhance our teaching.”

The participants were separated into new (<5 years of teaching experience), intermediate (5-15 years of teaching experience), and experienced (>15 years of teaching experience) categories to assess the teachers’ changes in practice. The new teachers tended to focus on making curriculum relevant to their students and building community in their classrooms. The experienced teachers

were more likely to mention the professional development validated their teaching philosophy and motivated them to try new things such as service learning projects. For example, one experienced teacher participant commented, “Ethnomathematics focuses on valuing people and the knowledge they bring. It has opened my eyes to various types of culture not just Hawaiian, but math culture, art culture, science culture...the service learning projects that we did will always be ingrained in my mind because the people I was surrounded by made it easy to learn and also to LOVE learning. They showed me how we can give back and take care of the land and culture and feel good about it. It reeled me back into a culture that I know and am proud of.”

Further Discussion

Due to its geographical position, Hawai‘i often serves as a gateway between the mainland U.S. and Pacific. Through research and praxis, we actively seek opportunities to interact and collaborate, and hold a shared belief *ma ka hana ka ‘ike* (in working one learns). The Mālama Honua Worldwide Voyage and Ethnomathematics and STEM Institute have strived to engage P–20 educators on significant themes to expand our network of strategic partners, including the University of Hawai‘i System, Hawai‘i State Department of Education, Hawai‘i P–20 Partnerships for Education, Pacific American Foundation, Pacific Resources for Education and Learning, and Polynesian Voyaging Society. These efforts have led to successful outcomes both within and outside of the classroom, and offer insights into next steps. Through research-based design and implementation of effective indigenous STEM professional development, culturally responsive methods are being transferred directly into P–20 classrooms.

In the future, as outlined by the National Science and Technology Council’s Federal STEM Education 5-Year Strategic Plan (2013), we will expand our approaches “to enable research and development at all levels on STEM instructional strategies, learning in informal environments,

and ways to improve professional development of teachers and faculty” (p. 4). We will invite and involve larger communities to mālama honua collectively as we build indigenous-serving, strengths-based alliances in our voyages on land and sea. Through continued efforts, the common denominator of our work remains the same—the children remind us why we do the things we do, and help us envision beyond the horizon. As it says on the backbeam of the Hōkūle‘a canoe, *kapu nā keiki* (hold sacred the children).

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